SYSTEM AND METHOD FOR DRAWING FLUID INTO A HELICOPTER BUCKET

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to a system and method for drawing fluid into a helicopter bucket, more particularly, for drawing fluid into a helicopter fire fighting bucket from a shallow fluid source

2. Description of Related Art

Helicopter fire fighting buckets are usually filled by dipping them into a body of water while suspended beneath a hovering helicopter. Various types of buckets are known. For example, commonly owned United States Patent No. **5,829,809** to Arney, the disclosure of which is incorporated herein by reference, shows a collapsible bucket suspendable beneath a helicopter to deliver water to a fire. United States Patent No. **5,560,429** to Needham discloses another example of a collapsible fire fighting bucket. Commonly owned United States Patent No. **6,192,990** to Arney, the disclosure of which is incorporated herein by reference, discloses a bucket reservoir that may be either collapsible or rigid which includes a novel water release valve.

Generally, in order to fill the fire fighting bucket with water, the bucket must be completely submerged under water. In the case of a collapsible bucket, the bucket generally requires some upward velocity while underwater to fully expand the bucket. As such, a deep body of water is required to completely submerge a fire fighting bucket. A large bucket, for example, may require a body of water as deep as **15** feet.

In dry climates such as California and the Southern U.S. there are often no deep water sources. The only water source available in some places include shallow ponds, ditches or creeks. Thus, there is a need for a fire fighting bucket to retrieve water from a shallow water source.

Attempts have been made to satisfy the above need. For example, U.S. Patent No. **6,209,593** to Nichols Sr. provides a pump system for a helicopter tanker including an axial flow electric pump coupled to a lower end of a snorkel extending from an onboard storage tank. The snorkel is dipped into the water source to draw the water into the onboard storage tank. The onboard storage tank is generally mounted against the underside of a helicopter via an expensive certified assembly. These two types of systems also require a long snorkel to reach down to the water surface while allowing the helicopter to maintain sufficient altitude for safety. A long snorkel, in turn, requires a powerful pump capable of pumping against a relatively high head in order to draw the water a long distance into the storage tank in a relatively short time to minimize hovering of the helicopter. It is known to use electric pumps to deliver water through the snorkel, but such pumps tend to be low volume and have a long fill time. Consequently, such systems require the helicopter to hover at a fixed altitude for a long period which is difficult for the pilot and hard on the helicopter. Alternatively, the snorkel system can use a certified pump that is heavy, very expensive and requires power to be drawn from the helicopter's main engine. This in turn, reduces the hovering ability and safety of the helicopter.

SUMMARY OF THE INVENTION

Accordingly, there is a need for a low power and efficient way of drawing fluid into a helicopter fire fighting bucket from a shallow fluid source. The fire fighting bucket can be either a rigid or a collapsible container.

The present invention addresses the above needs by providing a helicopter system and method for drawing fluid into helicopter bucket by drawing fluid into a helicopter fire fighting bucket from a shallow fluid source.

In accordance with one aspect of the invention there is provided a helicopter bucket including a fluid holding vessel having a bottom suspended from the helicopter; and a submersible high volume, low head axial flow pump

mounted adjacent the bottom of the holding vessel for drawing fluid from a fluid source and delivering the fluid into the holding vessel, the axial flow pump extends along a central axis between an open upper end and an opposite open lower end serving as an inlet for the axial flow pump.

The helicopter bucket may include means for releasing fluid from the vessel. The means for releasing fluid from the vessel may include a valve which has an inner assembly including a base plate spaced apart from a top plate, the base plate and the top plate defining therebetween an open side portion of the inner assembly, the base plate defining an outlet; and, an outer assembly including solid side walls, the outer assembly being movable with respect to the inner assembly between an open position and a closed position, an upper portion of the solid side walls being adapted to sealably cooperate with the top plate only when the outer assembly is in the closed position, a lower portion of the solid side walls being adapted to sealably cooperate with the base plate only when the outer assembly is in the closed position, wherein in the open position flow through the valve is permitted through the open side portion and the outlet of the outer assembly, and in the closed position flow through the valve is prevented by sealing engagement between the solid side walls of the outer assembly and the top plate and by engagement between the solid side walls and the base plate of the inner assembly.

The axial flow pump is powered by a power source. The power source may be the helicopter's electrical or hydraulic system, or may be a battery. The axial flow pump may be mounted inside of the bottom of the holding vessel, inside the valve, or may be mounted outside of the bottom of the holding vessel. The axial flow pump may also be moveable to a lowered position below the bottom of the holding vessel.

The axial flow pump may include a pump motor mounted adjacent the lower end of the axial flow pump; a water proof power cable connected to the pump motor and the power source, the power cable may be of sufficient length so that power may be delivered to the pump motor when the axial flow pump is in

the lowered position; an output drive shaft extending from the motor along the central axis; an impeller mounted on the drive shaft for driven rotation therewith; a motor to pump adapter to provide a mount for the pump, to center the output drive shaft with the impeller and provide protection against water ingress along the output shaft; a recuperator for directing the flow of water through the axial flow pump, allowing the pump motor to pump at high volumes with lower power; a filter screen mounted adjacent the lower end of the axial flow pump to filter fluid as the fluid is drawn into the axial flow pump; and a flap valve mounted adjacent the upper end of the axial flow pump to provide the fluid with a unidirectional flow through the axial flow pump.

The helicopter bucket may further include a hose attached to the upper end of the axial flow pump and the inside of the holding vessel, the hose being of sufficient length so that fluid may be delivered into the holding vessel when the axial flow pump is in the lowered position.

The helicopter bucket may further include a protective guard attached adjacent the lower end of the axial flow pump to protect the axial flow pump from damage during operation.

The helicopter bucket may further include a load cell in communication with the axial flow pump for signaling the axial flow pump to automatically stop drawing fluid into the holding vessel when a predetermined amount of fluid has been drawn into the holding vessel. The load cell may alternatively be in communication with the helicopter for providing an operator of the helicopter a representation of an amount of fluid drawn into the holding vessel.

Additionally or alternatively, a level switch may be in communication with the helicopter for providing an operator of the helicopter a representation of an amount of fluid drawn into the holding vessel. The level switch may, alternatively, be in communication with the axial flow pump for signaling the axial flow pump to automatically stop drawing fluid into the holding vessel

when a predetermined amount of fluid has been drawn into the holding vessel.

In accordance with another aspect of the invention there is provided a method for filling a helicopter bucket including suspending a fluid holding vessel, having a bottom, from the helicopter; and drawing fluid from a fluid source by using the submersible high volume, low head axial flow pump located adjacent the bottom of the holding vessel and delivering the fluid into the holding vessel.

The method may further include using power from the helicopter's electrical system to power the submersible high volume, low head axial flow pump. Alternatively, power from the helicopter's hydraulic system may be used to power the submersible high volume, low head axial flow pump. In a further alternative, a battery may be used to power the submersible high volume, low head axial flow pump.

The fluid may be drawn from inside the bottom of the holding vessel or may be drawn from outside the bottom of the holding vessel. The fluid may also be drawn from a lowered position below the bottom of the holding vessel. The method may further include delivering fluid to the holding vessel while drawing fluid from the lowered position.

The method may further include protecting the holding vessel against damage adjacent to where the fluid is being drawn.

The method may also include automatically stopping the drawing of fluid into the holding vessel when a predetermined amount of fluid has been drawn into the holding vessel or providing an operator of the helicopter a representation of an amount of fluid drawn into the holding vessel.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of

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specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In drawings which illustrate embodiments of the invention,

Figure **1** is an illustration of a preferred embodiment of the helicopter bucket attached to the underside of a helicopter with a break-away portion showing the inside of a holding vessel

Figure **2** is an illustration of the helicopter bucket Figure **1** which has been lowered into a pool of fluid

Figure **3** is an illustration of an alternative embodiment of the helicopter bucket with a break-away portion depicting a flexible valve and pumps located underneath of the holding vessel

Figure **4** is an illustration of an alternative embodiment of the helicopter bucket with a rigid holding vessel and a break-away portion depicting a butterfly valve

Figure **5** is an illustration of an alternative embodiment of the helicopter bucket with a rigid holding vessel and a break-away portion depicting a flapper valve

Figure **6** is an illustration of an alternative embodiment of the helicopter bucket with extendable pumps and a break-away portion showing the inside of a holding vessel

Figure **7** is an exploded view of an embodiment of an axial pump

Figure **8** is a cutaway perspective view of a holding vessel and an outer assembly and an embodiment of a valve and axial pump

DETAILED DESCRIPTION

Referring to Figure **1**, a helicopter bucket according to a preferred embodiment of the invention is shown generally at **10**. Apparatus **10** is suspended from a helicopter **14** via a suspension cable **11**. Cable **11** attaches to a cargo hook **13** of helicopter **14**. Apparatus **10** includes a fluid holding vessel **12** and a submersible high volume, low head axial flow pump **16** mounted adjacent the bottom of holding vessel **12**. Holding vessel **12**

illustrated in Figures **1** and **2** incorporates the patented valve described in commonly owned United States Patent No. **6,192,990**. The valve is essentially concerned with releasing water from the vessel while the present invention is directed to efficiently and reliably filling holding vessel **12**.

As illustrated in Figures **1**, **2**, **3** and **6**, holding vessel **12** may be a collapsible bucket. However, as illustrated in Figures **4** and **5**, holding vessel **12** may also be a rigid bucket.

Referring to Figures **1** and **2**, axial flow pump **16** extends along a central axis between an open upper end and an opposite open lower end serving as an inlet for the pump. Axial flow pump **16** connects to a water proof power cable **15**. Power for axial flow pump **16** may be provided by the helicopter's electrical system. For example, on small and medium sized helicopters axial flow pump **16** may be driven by a high efficiency permanent magnet DC motor (not shown) powered directly from the helicopter's nominal **28** volt electrical system. Alternatively, axial flow pump **16** may be powered by a battery pack located onboard the helicopter to render the pump independent of the helicopter's power system. On larger helicopters which have a more powerful AC electrical system, the motor may be an AC motor. In some cases, helicopters may already be fitted with onboard hydraulic systems for powering spreaders and seeders, for example. On such helicopters, axial flow pump **16** may be powered by the helicopter's hydraulic system.

Apparatus **10** further includes means for releasing fluid from holding vessel **12**. As those skilled in the art will appreciate, the means for releasing fluid from the vessel may include simply tilting holding vessel **12** or providing a closeable opening. In the present embodiment, the means for releasing fluid from holding vessel **12** includes a valve which may be a flexible valve **33** as illustrated in Figure **3**. In this embodiment, flexible valve **33** is controlled via operating cable **24**. Valve **33** is shown generally in U.S. Patents 4,474,245; 4,576,237; and 5,560,429. Valve **33** is held closed by a trip line (not shown) which holds the valve up against the water pressure in holding vessel **12** and

uses purse strings (not shown) attached to the trip line to clamp the valve closed. When the trip line is released by control head **22**, valve **33** inverts outwards through a hole **35** in the bottom of holding vessel **12**, allowing the water to escape. When refilling holding vessel **12**, the trip line is pulled in by control head **22** and latches. When the holding vessel **12** is lifted by a helicopter, the weight of water pressing down on valve **33** tightens the trip line and the purse strings and reseals the top of the valve. In an alternative embodiment the valve may be a butterfly valve **43** as illustrated in Figure **4**. In this embodiment, butterfly valve **43** includes a rocker plate **110** connected to holding vessel **12** via a pin **112**. To open or close butterfly valve **43**, an operator merely pivots rocker plate **110** about pin **112**. In yet another embodiment, the valve may be a flapper valve **53** as illustrated in Figure **5**. In this embodiment, flapper valve **53** includes flap plates **114** connected to holding vessel **12** via a hinge pin **116**. To open or close flapper valve **53**, an operator merely pivots flap plates **114** about hinge pin **116**. As those skilled in the art will appreciate, similar means for releasing fluid from the vessel may also be used. Preferably, the means for releasing fluid from the vessel is a multi-dump metering valve **18** as illustrated in Figures **1** and **2** and fully described in United States Patent No. **6,192,990.**

Referring to Figures **1** and **2**, suspension lines **20** suspend holding vessel **12** from a control head **22**. Operating cable **24** controls multi-dump metering valve **18** and attaches to control head **22**.

Referring to Figures **2** and **8**, multi-dump metering valve **18** may include an inner assembly **99** including a base plate **100** spaced apart from a top plate **102**. Base plate **100** defines an outlet **105**. There is an outer assembly **103** which includes solid side walls **104**. Outer assembly **103** is movable with respect to inner assembly **99** between an open position, as illustrated in Figure **1**, and a closed position, as illustrated in Figures **2** and **8**. Referring to Figure **1**, in the open position, flow through the valve is permitted through open side portion **107** of inner assembly **99** and outlet **105** of base plate **100**. Referring to Figures **2** and **8**, in the closed position, flow through the valve is

prevented by sealing engagement between solid side walls **104** of outer assembly **103** and top plate **102** and by sealing engagement between solid side walls **104** and base plate **100** of inner assembly **99**.

Figure **7** illustrates an exploded view of a preferred embodiment of axial flow pump **16**. In this embodiment, axial flow pump **16** includes a pump motor **60** mounted adjacent the lower end of axial flow pump **16**. Water proof power cable **15** is connected to pump motor **60**. An output drive shaft **64** extends from motor **60** to drive an impeller **66** for rotation therewith. A motor to pump adapter **68** is used to provide a mount for pump motor **60**, to center output drive shaft **64** with impeller **66** and provide protection against water infiltration along output shaft **64**. To provide protection against water infiltration along output shaft **64**, adapter **68** incorporates a secondary self centering seal [not illustrated]. A cavity between the secondary self centering seal and the seal of pump motor **60** can be purged with grease through a nipple [not illustrated] in adapter **68**. Axial flow pump **16** also includes a recuperator **70** for directing the flow of water through axial flow pump **16**, allowing pump motor **60** to pump at high volumes with lower power. Fluid that is pumped into recuperator **70** exits via an exit duct **72**. A flap valve **74** mounted adjacent the upper end of exit duct **72** ensures that the fluid flows through axial flow pump **16** in a unidirectional manner into holding vessel **12**. A filter screen **76** is also provided to filter fluid as it is drawn into axial flow pump **16**. In the illustrated embodiment, filter screen **76** is mounted adjacent impeller **66**.

As illustrated in the preferred embodiment of Figure **8**, axial flow pump **16** is mounted inside of multi-dump metering valve **18**. By placing axial flow pump **16** inside of multi-dump metering valve **18**, valve **18** serves to protect axial flow pump **16** from damage when holding vessel **12** is lowered or swings into obstructions. In this embodiment, adapter **68** is connected to the underside of top plate **102** of multi-dump metering valve **18** to mount pump motor **60** below top plate **102**. Impeller **66** along with filter **76** are placed within recuperator **70**. Recuperator **70** is then placed through top plate **102**, allowing exit duct **72** and flapper valve **74** to be positioned above top plate **102** to provide a path for

fluid to enter holding vessel **12** while multi-dump metering valve **18** is in the closed position. Figure **8** shows two axial flow pumps in operation, however, it will be appreciated by those skilled in the art that one or several axial flow pumps may be employed depending on a number of circumstances, including, the size of a holding vessel and the amount of fluid required to fill the holding vessel.

As illustrated in Figures **1**, **2**, and **4** axial flow pump **16** may be mounted inside of the bottom of holding vessel **12**. However, depending upon an operator's needs, axial flow pump **16** may be mounted externally to the bottom of holding vessel **12** as illustrated in Figures **3** and **5**. For example, since space is limited in small holding vessels, it may be necessary to mount axial flow pump **16** externally to the bottom of holding vessel **12** so that the interior of holding vessel **12** can be dedicated to holding fluid.

As best shown in Figure **4**, a protective guard **45** may be attached adjacent the lower end the axial flow pump **16** to protect the axial flow pump **16** from damage during operation.

Apparatus **10** may also have the ability to set the amount of fluid in holding vessel **12** and hence the overall load helicopter **14** has to lift. This feature is very important at higher altitudes or in very hot conditions when helicopter **14** cannot pickup its full rated load. Referring to Figure **1**, apparatus **10** may include a load cell **109**, attached to cargo hook **13**, in communication with axial flow pump **16.** Load cell **109** may signal axial flow pump **16** to automatically stop drawing fluid into holding vessel **12** when a predetermined amount of fluid has been drawn into holding vessel **12.** Alternatively, load cell **109** may provide an operator of helicopter **14** a representation of an amount of fluid drawn into holding vessel **12**. The operator can then determine whether to stop axial flow pump **16** from further drawing fluid into holding vessel **12**. In an alternative embodiment, as best shown in Figure **2**, a level switch **26** may be in communication with axial flow pump **16.** Level switch **26** may signal axial flow pump **16** to automatically stop drawing fluid into holding

vessel **12** when a predetermined amount of fluid has been drawn into holding vessel **12.** Alternatively, level switch **26** may provide an operator of helicopter **14** a representation of an amount of fluid drawn into holding vessel **12**. The operator can then determine whether to stop axial flow pump **16** from further drawing fluid into holding vessel **12**.

<u>Operation</u>

Referring to Figure **2**, apparatus **10** is lowered into a pool of fluid **28** to allow axial flow pump **16** to draw fluid into holding vessel **12**. Because axial flow pump **16** is adjacent the bottom of holding vessel **12**, axial flow pump **16** has a short vertical distance to move the fluid into holding vessel **12**. This greatly reduces the power required to draw the fluid as compared to conventional systems, for example, long snorkel and belly tank systems as mentioned above.

Referring to Figures **2** and **8**, in the preferred embodiment, outer assembly **103** is initially in the closed position. In order to draw the fluid into holding vessel **12**, apparatus **10** should be lowered so that impeller **66** is submersed within the fluid. Outlet **105** allows the fluid to enter multi-dump metering valve **18** so that the fluid can then be drawn through recuperator **70** to exit via exit duct **72** into holding vessel **12**. Since outer assembly **103** is in the closed position, the fluid is maintained within holding vessel **12**. Referring to Figure 1, to release the fluid, the operator actuates operating cable **24** to raise outer assembly **103** into the open position, allowing the fluid to pass through open side portion **107** of inner assembly **99** and outlet **105** of base plate **100**.

Should apparatus **10** be required to operate in an area with a very shallow or small fluid source, for example in irrigation ditches running between fields or roadside ditches in rural areas, axial flow pump **16** may be moveable to a lowered position below the bottom of holding vessel **12**, as best shown in Figure **6**. In the preferred embodiment, axial flow pump **16** may be connected to multi-dump metering valve **18** via a Kam Lock type clamp for easy removal of axial flow pump **16** from multi-dump metering valve **18**. The Kam Lock type

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clamp is manually operated to release axial flow pump **16** from holding vessel **12** before takeoff of helicopter **14**. Additionally, apparatus **10** may further include a hose **30** attached to the upper end of axial flow pump **16** and the inside of holding vessel **12**. Hose **30** is of sufficient length so that fluid may be delivered into holding vessel **12** when axial flow pump **16** is in the lowered position. In this embodiment, because holding vessel **12** is suspended from helicopter **14** after takeoff, holding vessel **12** is close to the fluid source. As such, a short hose for example, **2** feet in length, may be used. Using such a short hose overcomes the disadvantages associated with aforementioned snorkel arrangements, which require long snorkels to fill an onboard storage tank. Additionally, in this embodiment, waterproof power cable **15** may be of sufficient length so that power may be delivered to pump motor **60** when axial flow pump **16** is in the lowered position.

While specific embodiments of the invention have been described and illustrated, such embodiments should be considered illustrative of the invention only and not as limiting the invention as construed in accordance with the accompanying claims.